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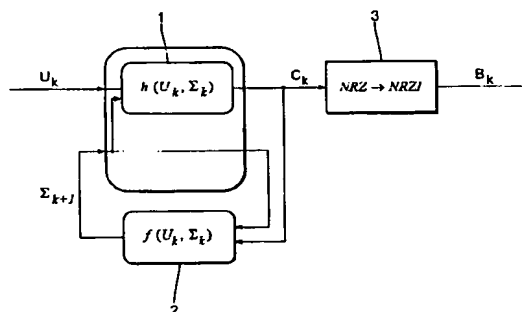
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(54) Title: METHOD AND APPARATUS FOR MULTI-DimensionALLY ENCODING AND DECODING



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(57) Abstract: The invention relates to a method of multi-dimensionally encoding a user data stream of user words into a channel data stream of channel words evolving in a one-dimensional direction of infinite extent. The invention relates further to a corresponding method of decoding. In order to implement certain two- or multi-dimensional coding constraints and coding geometries which lead to higher storage densities and improve the coding efficiency, a method of encoding is proposed wherein:- a user word is encoded into an NRZ channel word by selecting said NRZ channel word from a code table depending on said user word and the current state of an underlying finite-state-machine, wherein an NRZ channel word comprises a sequence of NRZ channel symbols of NRZ channel bits having a one-dimensional interpretation along said one-dimensional direction and wherein states of an underlying finite-state-machine describing the characteristics of the multi-dimensional code are defined by NRZI channel bits of the previous channel word and by NRZ channel symbols of the current channel word,- the NRZ channel symbols are transcoded into NRZI channel symbols by a one-dimensional 1T-precoding operation including an integration modulo 2, said 1T-precoding operation being carried out along said one-dimensional direction of infinite extent, and - said finite-state-machine is put into a new state selected from said code table depending on said user word and the current state of said finite-state-machine together with encoding a user word into a channel word.



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*For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.*

INTERNATIONAL SEARCH REPORT

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A. CLASSIFICATION OF SUBJECT MATTER  
IPC 7 G11B20/14

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)  
IPC 7 G11B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category * | Citation of document, with indication, where appropriate, of the relevant passages   | Relevant to claim No. |
|------------|--|-----------------------|
| A          | <p>WEEKS W: "Full-Surface Data Storage"<br/>           THESIS SUBMITTED IN PARTIAL FULFILLMENT OF<br/>           THE REQUIREMENTS FOR THE DEGREE OF DOCTOR<br/>           OF PHILOSOPHY IN ELECTRICAL ENGINEERING IN<br/>           THE GRADUATE COLLEGE OF THE UNIVERSITY OF<br/>           ILLINOIS AT URBANA- CHAMPAIGN, XX, XX,<br/>           2000, page complete XP002227664<br/>           page 1, line 1 -page 99, last line<br/>           page 3.2.4; figures 3.7-3.9</p> <p style="text-align: center;">---<br/>-/-</p> | <p>1,8,<br/>28-32</p> |

☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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- \*&\* document member of the same patent family

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| C(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT |   |                       |
|---|---|-----------------------|
| Category *  | Citation of document, with indication, where appropriate, of the relevant passages  | Relevant to claim No. |
| A   | WEEKS W ET AL: "The capacity and coding gain of certain checkerboard codes"<br>IEEE TRANSACTIONS ON INFORMATION THEORY,<br>IEEE INC. NEW YORK, US,<br>vol. 44, no. 3, May 1998 (1998-05), pages<br>1193-1203, XP002227665<br>ISSN: 0018-9448<br>page 1193, column 2, line 1 -page 1203,<br>column 2, last line<br>----- | 1,8,<br>28-32         |
| A   | MARCUS B H ET AL: "FINITE-STATE<br>MODULATION CODES FOR DATA STORAGE"<br>IEEE JOURNAL ON SELECTED AREAS IN<br>COMMUNICATIONS, IEEE INC. NEW YORK, US,<br>vol. 10, no. 1, 1992, pages 5-37,<br>XP000462064<br>ISSN: 0733-8716<br>page 5, column 1, line 1 -page 37, column<br>1, last line<br>-----                      | 1,8,<br>28-32         |
| L   | WO 03 034596 A (OPHEY WILLEM G ;COENE<br>WILLEM M J M (NL); KONINKL PHILIPS<br>ELECTRONI) 24 April 2003 (2003-04-24)<br>cited in the application<br>page 1, line 1 -page 15, last line;<br>figures 1-15<br>-----  | 1,8,<br>28-32         |

## INTERNATIONAL SEARCH REPORT

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| Patent document<br>cited in search report |   | Publication<br>date | Patent family<br>member(s) | Publication<br>date |
|---|---|---------------------|----------------------------|---------------------|
| WO 03034596                               | A | 24-04-2003          | WO 03034595 A1             | 24-04-2003          |
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